Using biochemical and growth parameters to assess soybean yieldpotential

ABSTRACT

This investigationwas conducted at the All India Coordinated Research Project on SoybeanDharwad in 2022 to assess soybean yield potential using biochemical and growth parameters. Ten soybean genotypes including three checks were evaluated in a randomized block design. Chlorophyll content varied across growth stages with DLSb 3, DSb 34 and DSb 23 showing highest results. Absolute growth rate (AGR), Crop growth rate (CGR), Relative growth rate (RGR), and Net assimilation rate (NAR) exhibited significant genotype differences. DSb 34 and DLSb 5 had the highest AGR and CGR at 60-90 DAS. RGR was highest in DSb 39 at 30-60 DAS but decreased with crop age. NAR peaked at 60-90 DAS with DLSb 1 showing the highest values. Yield components analysis revealed DLSb 5and DSb 34 as the highest-yielding genotypes with significant variation in the number of pods per plant among genotypes. These findings highlight key traits for soybean yield improvement.

Keywords

Chlorophyll, Yield, Soybean

INTRODUCTION

Soybean (*Glycine max* (L.) Merrill) is a legume crop belonging to the family Fabaceae and the subfamily Papilionaceae. It is an important pulse as well as an oilseed crop. Soybean is considered as the king of beans due to its high protein and oil content in the seed which is approximately 40% and 20%, respectively. In India 11.44 m ha area is under soybean cultivation with production and productivity of 12.04 m t and 1052 kg ha^{-1} respectively (SOPA., 2022). The major soybean growing states in India are Madhya Pradesh, Maharashtra, Rajasthan, Andhra Pradesh, Karnataka and Gujarat. The area, production and productivity of soybean in Karnataka are 0.43 m ha, 0.44 m t and 1055 kg ha^{-1}respectively (SOPA., 2023). Variation in dry matter accumulation and pod production among different genotypes can be attributed to factors such as crop growth rate (CGR), net assimilation rate (NAR) and relative growth rate (RGR). Optimal Leaf area index (LAI) and Net assimilation rate (NAR) in a plant may result in higher biological

yield and seed yield (Mondal *et al*.,2007). The lower yield of soybean, despite its status as a stable and economically viable *kharif* crop, poses a major challenge for soybean cultivation. The availability of high-yielding and stable soybean genotypes suitable for different agro-climatic regions is a significant constraint. Crop yield is a complex trait influenced by various genetic, biochemical and growth factors. The existence of uncertain constraints, such as lower sink demand leads to a significant gap in achieving critical yield levels, resulting in the stagnation of genetic yield potential.

MATERIAL AND METHODS

The present investigation on "Using biochemical and growth parameters to assess soybean yieldpotential" was conducted at All India Coordinated Research Project on Soybean, Main Agriculture Research Station, University of Agricultural Sciences, Dharwad. The experimental material comprised of ten soybean genotypes including three checks. Seven soybean genotypes were DSb 38, DSb 39, DSb 40, DLSb 1, DLSb 3, DLSb 4 and DLSb 5. Additionally, three checks, namely DSb 23, DSb 34 and JS 335 were included in the study. The field experiment was laid out in randomized block design and three replications as per the plan of the experiment. Gross plot size was 7.2 m^2 and net plot size was 4.8 m^2. The plants were sown with inter row spacing 30 cm and intra row spacing 10 cm.

RESULT AND DISCUSSION

A. Performance of soybean genotypes for biochemical Parameter

The performance of different soybean genotypes for biochemical parameter is presented in Table 1.

I. Chlorophyll content

Chlorophyll content in soybean genotypes varied throughout the growth period. At 30 days after sowing (DAS), DLSb 3 had the highest chlorophyll *a*, DSb-34 had the highest chlorophyll *b* and DLSb-34 had the highest total chlorophyll. At 60 DAS, the genotypes were similar for chlorophyll *a* except DLSb 4, which had the lowest chlorophyll *a*, chlorophyll *b* and total chlorophyll. DSb 34 had the highest chlorophyll *b* and total chlorophyll at 60 DAS. At 90 DAS, DLSb 5 and DSb 34 had the highest chlorophyll *a*,DSb 38 had the highest chlorophyll *b* and DSb 23 had the highest total chlorophyll. DSb 38 had the lowest chlorophyll *a* and

chlorophyll *b*and DSb 34 had the lowest total chlorophyll at 90 DAS.Total chlorophyll content of all soybean genotypes increased from 30 to 60 DAS, but then decreased until maturity. This is consistent with the findings of Patel (1968) and Betzelberger*et al*. (2010) who found a positive correlation between chlorophyll content and yield.

B. Performance of soybean genotypes for growth parameters

I. Absolute growth rate (AGR)

Variation in AGR was significant among the genotypes during the growth stages, as detailed in Table 2. The absolute growth rate gradually increased with crop age and reached its peak during60 to 90 DAS. The maximum AGR wasobserved at 60-90 DAS in all genotypes and at this stage highest AGR of 0.5871 g $day^{-1}$was recorded by DSb 34 which was on par with DLSb 5 (0.5809 g day^{-1}). The minimum AGR was recorded in the genotypeDSb 40 (0.4967g day^{-1})on par withDSb 38(0.5065 g day^{-1}) and DSb 23 (0.5141 g day^{-1}).The higher light interception was exhibited in DSb 34 and DLSb 5 between 60 to 90 DAS, lead to increased photosynthetic rate and dry matter production, which in turn increases the AGR. The present findings are in agreement with Deokar*et al.* (2009) andMalek*etal*.(2012) who reported that larger LAI as well as increased AGR at all growth stages were identified as essential traits for a high-yielding soybean genotype.

II. Crop growth rate (CGR)

Throughout the growth stages, significant variation in CGR was observed among the genotypes as indicated in Table 2. The crop growth rate gradually increased with crop age and reached its peak during60 to 90 DAS. The maximum CGR wasobserved at 60-90 DAS in all genotypes and at this stage highest CGR of 19.57 g m^{-2} day^{-1} was recorded by DSb 34 which was on par with DLSb 5 (19.36 g m^{-2} day^{-1}). The minimum CGR was recorded in the genotypeDSb 40 (16.55g m^{-2} day^{-1})on par withDSb 38(16.88 g m^{-2} day^{-1}) and DSb23 (17.14 g m^{-2} day^{-1}).DSb 34 and DLSb 5 had the highest crop growth rate (CGR) between 60 to 90 days after sowing (DAS), while DSB 40 had the lowest. This was because DSb 34 and DLSb 5 had higher LAI values and light interception during that period. The higher LAI values and light interception led to increased photosynthetic rate and dry matter production, which in turn increased the CGR. A

higher CGR was observed after the flowering stage in soybean genotypes(Pedersen and Lauer, 2004) [8]. However, the CGR decreases after reaching its maximum value until maturity due to leaf aging and abscission and there was a positive correlation between crop growth rate (CGR) and grain yield per plant. The present findings are in agreement with Dogra*etal.*(2015) and Varsha *et al.* (2020) who reported the same.

III. Relative growth rate (RGR)

Significant differences in RGR were observed among soybean genotypes throughout the growth period (Table 2). The highest RGR occurred at 30-60 DAS in DSb39 (0.0555 g g^{-1} day^{-1}) which was on par with DSb 34 (0.0554 g g^{-1} day^{-1}) and DLSb 1 (0.0553 g g^{-1} day^{-1}), while DSb 40 had the lowest (0.0526 g g^{-1} day^{-1}). RGRdecreased with the age of crop. The decreaseinRGR values between 60 DAS to harvest may be attributed to senescence of leaves. At 60 to 90 DAS, relative growth rate (RGR) was higher in DLSb 1 which was the low yielding genotype and the lowest RGR was recorded in DSb 40 which was the fourth high yielding genotype. A genotype with a high RGR does not always produce a high yield.The present findings are in agreement with Malek *et al*. (2012) who reported that there is no relation between RGR and seed yield.Relative growth rate (RGR) declined with increasing age in all genotypes and it decreased rapidly from 60 to 90 DAS till physiological maturity due to the senescence of leaves and a reduction in SCMR which can lead to a decrease in photosynthetic rate and total dry matter. Salam *et al*. (1987) suggested that RGR declined at later growth stages (reproductive stage) which may be attributed to excessive mutual shading as the LA was maximum during this period and increased number of old leaves could have lowered the photosynthetic efficiency. Hamid *et al*. (1991) reported sharp decline in RGR during reproductive stage was probably due to increased demand of assimilate by the growing seed fraction. A similar decline in RGR with the age of crop has been reported byTandale andUbale (2007)andVyasandKhandwe(2014).

IV. Net assimilation rate (NAR)

There was significant difference for NAR among thesoybeangenotypesthroughoutthecropgrowthperiodaspresented in Table 2. At 60-90 DAS the highest NAR was recorded in DLSb 1 (0.0557 g dm^{-2} day^{-1}) which was on par with DSb 34

(0.0545 g dm^{-2} day^{-1}) and DSb 38 (0.0545 g dm^{-2} day^{-1}) and minimum wasrecorded in genotype DSb 39 (0.0473 g dm^{-2} day^{-1}) which was on par with JS 335 (0.0479 g dm^{-2} day^{-1}). The NAR was maximum at 60-90 DAS. The soybean genotypes showed significant variation for net assimilation rate (NAR) from 30-60 DAS to 60-90 DAS. NAR increased from 30-60 DAS to 60-90 DAS. At 60 to 90 DAS, NAR was higher in DLSb 1 and the lowest NAR was recorded in DSb 39. Rajput and Shrivastava (1991) reported the genotypic difference with respect to NAR in soybean. The result was in accordance with the findings of Deokar et al. (2009).

C. Performance of soybean genotypes for yield components

I. Yield (q/ha)

The data on seed yield of the soybean genotypes is presented in Table 3. It has shown that the seed yield among the genotypes varied significantly. The highest seed yield was (31.21 q/ha) recorded by the genotype DLSb 5 followed by DSb 34 (29.34 q/ha) and the lowest seed yield (18.83 q/ha) was obtained from the genotype DLSb 1.

II. Number of pods per plant

The data on number of pods per plant is presented in Table 3, reveals a variation among soybean genotypes. Notably, the genotype DLSb 5 recorded the highest number of pods per plant (63.20), while the lowest count (44.07) was observed in genotype DLSb 1 which was on par (45.47) with DLSb 4.

The soybean genotypes had significant differences in the number of pods per plant. DLSb 5 had the highest number of pods per plant which significantly gave higher seed yield, followed by DSb 34. DLSb 1 and DLSb 4 had the lowest number of pods per plant, with no significant difference between them. The number of pods per plant is a major contributor to grain yield. Oz *et al*. (2009) observed significant positive correlations between seed yield and the number of pods per plant. The result was in accordance with the findings of Ali *et al*. (2013).

Table 1. Mean performance of soybean genotypes for chlorophyll content (mg g^{-1} fresh wt) at 30, 60 and 90 DAS

Genotype	30 DAS			60 DAS			90 DAS		
	Chlorophyll			Chlorophyll			Chlorophyll		
	a	***b***	**Total**	***a***	***b***	**Total**	***a***	***b***	**Total**
DSb 38	1.144	0.508	1.651	1.720	1.079	2.800	0.933	1.169	2.102
DSb 39	1.267	0.527	1.794	1.660	0.893	2.553	1.531	0.913	2.445
DSb 40	1.217	0.614	1.831	1.666	0.888	2.554	0.962	0.424	1.386
DLSb 1	1.141	0.504	1.645	1.628	0.761	2.389	1.816	0.544	2.360
DLSb 3	1.346	0.534	1.880	1.714	0.990	2.704	1.130	0.746	1.876
DLSb 4	1.142	0.336	1.478	1.465	0.648	2.113	1.504	0.837	2.342
DLSb 5	1.264	0.573	1.838	1.734	1.128	2.862	1.847	0.261	2.108
DSb 34 (C)	1.237	0.676	1.913	1.742	1.201	2.942	1.847	0.242	2.090
DSb 23 (C)	1.181	0.519	1.700	1.655	0.685	2.340	1.820	1.037	2.857
JS 335 (C)	1.189	0.560	1.748	1.721	1.088	2.809	1.359	0.991	2.351
Mean	**1.212**	**0.535**	**1.747**	**1.670**	**0.936**	**2.606**	**1.474**	**0.716**	**2.191**
SEm±	0.036	0.016	0.053	0.050	0.046	0.096	0.099	0.038	0.097
CD(P=0.05)	0.109	0.048	0.157	0.150	0.136	0.286	0.295	0.112	0.288

Table 2. Absolute growth rate (AGR), Crop growth rate (CGR), Relative growth rate (RGR) and Net assimilation rate (NAR) in soybean genotypes at 30-60 DAS and 60-90 DAS

Genotype	AGR ($g\ day^{-1}$)		CGR ($g\ m^{-2}\ day^{-1}$)		RGR ($g\ g^{-1}\ day^{-1}$)		NAR ($g\ dm^{-2}\ day^{-1}$)	
	30-60 DAS	**60-90 DAS**	**30-60 DAS**	**60-90 DAS**	**30-60 DAS**	**60-90 DAS**	**30-60 DAS**	**60-90 DAS**
DSb 38	0.3880	0.5065	12.93	16.88	0.0552	0.0240	0.0497	0.0545
DSb 39	0.4148	0.5679	13.82	18.93	0.0555	0.0249	0.0471	0.0473
DSb 40	0.3937	0.4967	13.12	16.55	0.0526	0.0231	0.0428	0.0524
DLSb 1	0.3671	0.5299	12.24	17.66	0.0553	0.0258	0.0505	0.0557
DLSb 3	0.4046	0.5235	13.49	17.45	0.0543	0.0238	0.0463	0.0524
DLSb 4	0.3919	0.5241	13.06	17.47	0.0541	0.0243	0.0492	0.0530
DLSb 5	0.4477	0.5809	14.92	19.36	0.0546	0.0239	0.0432	0.0491
DSb 34 (C)	0.4275	0.5871	14.25	19.57	0.0554	0.0249	0.0476	0.0545
DSb 23 (C)	0.3948	0.5141	13.16	17.14	0.0531	0.0237	0.0506	0.0528
JS 335 (C)	0.4304	0.5574	14.35	18.58	0.0551	0.0239	0.0465	0.0479
Mean	**0.4060**	**0.5388**	**13.53**	**17.95**	**0.054**	**0.0242**	**0.0473**	**0.0519**
SEm±	0.0063	0.0115	0.21	0.38	0.005	0.0005	0.0011	0.0015
CD(P=0.05)	0.0188	0.0340	0.62	1.13	0.001	0.0014	0.0033	0.0044

Table 3. Mean performance of soybean genotypes for yield components

Genotype	Pods/Plant	Yield (q/ha)
DSb 38	47.07	22.08
DSb 39	47.93	26.69
DSb 40	55.20	27.68
DLSb 1	44.07	18.83
DLSb 3	55.33	28.68
DLSb 4	45.47	23.76
DLSb 5	63.20	31.21
DSb 34 (C)	57.27	29.34
DSb 23 (C)	52.40	26.78
JS 335 (C)	51.67	25.12
Mean	**51.96**	**26.01**
SEm±	3.14	1.68
CD P=(0.05)	9.35	4.99

Conclusion

In the present study, ten soybean genotypes were evaluated for biochemical and growth parameters to identify the determinants of soybean yield. The results revealed that significant variation existed among the genotypes for all the studied parameters. The genotype DSb 34 had the highest chlorophyll content, AGR, CGR, NAR and seed yield, followed by genotype DLSb 5. The lowest values for all the parameters were recorded in genotype DSb 40. The results suggest that biochemical and growth parameters such as chlorophyll content, AGR, CGR and NAR are important determinants of soybean yield. These parameters can be used as selection criteria to develop high-yielding soybean varieties.

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